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PRACTICAL POINTERS ON MAKING CREAMERY BUTTER IN THE SOUTH

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INTRODUCTION

The manufacture of creamery butter in the Southern States is a relatively new industry. The quantity of creamery butter made in 1918 in Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, and Louisiana was 11,038,000 pounds, or 1.3 percent of the total production of creamery butter for that year in the United States. In 1931 the quantity produced in these States had increased to 57,864,000 pounds, or 3.47 percent of the total production. The operators of creameries in these States have had to contend with such conditions as small production of butterfat per square mile of country, small annual output of butter per creamery, high average atmospheric temperature, high average temperature of water on farms, and lack of experience on the part of those engaged in producing the cream and manufacturing the butter.

The Bureau of Dairy Industry, United States Department of Agriculture, has cooperated with the agricultural colleges of several Southern States in aiding the creamery managers and butter makers with their numerous problems. Manufacturing specialists of the Bureau have given personal assistance at many of the creameries, have instructed at creamery men's short courses at State colleges,

and have scored and determined the composition of butter samples at educational butter judgings held at various creameries in order to demonstrate the scoring and analyzing of the butter to the creamery men.

Since personal assistance at creameries can be given only occasionally, information of general application in southern creameries is presented in this publication. Special attention is given to the various defects found in the butter sent to the educational judgings and to methods of overcoming these defects.

DEFECTS OF BUTTER AND METHODS OF PREVENTING THEM

The data in table 1 on butter samples, developed in 2 years of educational butter judgings held in Alabama, will indicate the quality of the butter made in many southern creameries, and show the various defects found in these samples and their relative frequency of occurrence.

TABLE 1.—*Defects of butter and number of samples in which each defect was noted in butter entered in educational judgings in Alabama*

Defects	Samples showing defect	Defects	Samples showing defect	Defects	Samples showing defect
Flavor:	*Number*	Flavor—Continued	*Number*	Color:	*Number*
Old cream	26	Bitter	1	Mottled	4
Neutralizer	16	Feed	1	Wavy	3
Stale	15	Metallic	1	Curd specks	2
Weedy	6			Light	1
Oily	2	Total flavor defects	75	High	1
Yeasty	2			Salt, gritty	2
Unclean	1				
Cooked	1	Body:		Total body, color, and salt defects	41
High acid	1	Leaky	13		
Curdy	1	Gummy	11		
Rancid	1	Overworked	4		

FLAVORS CAUSED BY USING POOR-QUALITY CREAM

In these judgings the defect that appeared most frequently in the butter and that caused the greatest loss in number of points in the score was old-cream flavor. Some samples had defects closely allied to old-cream flavor, such as stale, yeasty, rancid, and other off flavors in butter which come from improper care of the cream before it reaches the creamery. It is evident, therefore, that adopting methods of raising the average quality of the cream delivered to many creameries is of great importance to the butter industry in Southern States.

Butter of the highest quality can be made only from cream that is received at the creamery fresh, sweet, and clean in flavor. Such butter meets the least sales resistance, brings the highest market price, and makes it possible to pay a correspondingly high price to the producers of high-quality cream. The average wholesale price of high-quality butter (93 score) on the New York City market for the 5 years 1927 to 1931, was 41.83 cents a pound, and the average price of low-quality butter (88 score) was 37.38 cents—a difference of 4.45 cents a pound.

This loss of 4.45 cents per pound of butter is the severe penalty paid for producing a low-quality product. To a farmer having a

few cows such a loss, in value of butterfat in poor-quality cream, might amount to between $50 to $100 a year, and to a creamery making 200,000 pounds of low-quality butter a year the annual loss would total nearly $9,000. Every creamery operator and creamery patron who suffers such a loss should give careful study to the problem of eliminating it. The question naturally arises as to what steps may be taken to bring about the desired result. The fact must be recognized that marked improvement in the average quality of cream delivered at a creamery can usually be obtained only by adopting a definite plan of procedure and by devoting much time and energy to carrying out that plan.

METHODS FOR RAISING AVERAGE QUALITY OF CREAM RECEIVED

GRADING AND BUYING CREAM ON A BUTTER-QUALITY BASIS

Experience at many creameries has shown that the most effective procedure for improving the quality of cream delivered to the creamery is to grade each delivery and pay for it on a basis of the quality of butter it will produce. As butter of the highest quality can be made only from fresh, sweet cream the creameryman can afford to pay a higher price for such cream than for that from which only low-grade butter can be made. Experience also shows that when a creamery pays the same price for old, sour cream as for fresh, sweet cream, it receives very little of the latter. This is natural because the delivery of fresh, sweet cream requires additional labor and expense, and the farmer cannot be expected even slightly to increase his cost of production unless he is to be repaid.

There is a great lack of uniformity in the requirements for the several grades of cream among creameries that have adopted grading systems for buying cream on the basis of the quality of butter that can be manufactured from it. Each creamery defines its grades to suit its particular conditions, except in those States where official grades have been established by law. It is natural that in a highly developed dairy section where the manufacture of high-quality butter is well established the grading of cream should be on a higher plane than in a section where dairying is carried on as a side line.

The following grade requirements are recommended for creameries in sections where much of the cream is sour when delivered to the creamery:

Grade 1. Cream from which the butter will score 92 points or higher. The cream shall be fresh and clean in flavor, the acidity shall not exceed 0.2 percent, and the fat content shall be not less than 30 percent nor more than 40 percent.

Grade 2. Cream from which the butter will score at least 90 points. The cream shall be clean in flavor, the acidity shall not exceed 0.4 percent, and the fat content shall be not less than 30 percent nor more than 40 percent.

Grade 3. Cream from which the butter will score at least 87 points. The cream may have undesirable and objectionable flavors but shall be free from strongly objectionable and foreign flavors such as onion, gasoline, and cheesy.

Grade 4. Cream that cannot meet the requirements of grade 3. Such cream should be rejected because butter made from filthy or badly decomposed cream cannot be sold legally as food.

The price paid to producers for butterfat in grade 2 cream should be at least 2 cents a pound less than that paid for butterfat in

grade 1 cream, and the price for butterfat in grade 3 cream should be at least 2 cents less than for butterfat in grade 2 cream. A greater difference in price between grades than these minimums will provide a still greater incentive for the delivery of high-grade cream.

OTHER FACTORS IN CREAM IMPROVEMENT

The adoption of a grading system, under which a premium is paid for high-quality cream, is not sufficient in itself to produce the best results. This must be accompanied by a carefully planned campaign to interest every patron of the creamery in the grading system, and to aid him in having his cream meet the highest requirements. The creamery manager will usually find it necessary to devote a great deal of time to this work, because many of his patrons may need individual instruction and advice to enable them to deliver high-quality cream. The creamery manager should also seek the cooperation of agencies active in agricultural work, especially the State agricultural extension service. It is logical that the extension service should participate in a cream-improvement program, as this is a means for the farmer to obtain an immediate increase in the income from his cows. County agricultural and home demonstration agents are the logical persons to visit the farmer and his wife and give them instructions on all phases of producing first-grade cream.

In order to deliver cream that is fresh, sweet, and fine in flavor the farmer, among other things, must (1) feed his cows in a manner that will avoid undesirable feed and weed flavors in the milk and cream; (2) have properly constructed utensils that are clean and in good condition; and (3) cool his cream promptly, keep it cold, and deliver it at the creamery four times a week. If no cooling facilities are available on the farm, the cream should be delivered daily.

The creamery manager should take the initiative in arranging for the most economical transportation of cream from the farm to the creamery, just as he should in making other phases of cream-improvement work effective.

One of the big problems for farmers who live several miles from the creamery and have only a few cows is how to deliver cream frequently without excessive cost of hauling. A farmer cannot afford to make a special trip of several miles with a small quantity of cream when the premium is insufficient to pay for the cost of transportation. The problem is often solved by getting three or more farmers to cooperate in taking turns in hauling their own and their neighbors' cream. Another plan is for one man to do all the hauling for his community and charge his neighbors a share of the cost, usually on a basis of the pounds of butterfat hauled. This is a cream-gathering route and, in sections where the number of cows per farm is small, is usually less expensive and more satisfactory than gathering cream with a creamery-operated truck. During the school term, children sometimes take cream to the creamery if it is on their way to school.

CARE OF CREAM IN THE FACTORY

Keep high-quality cream separate from low-quality cream. It is usually not practicable to make more than two grades of butter at

a creamery. Grade 1 cream should be churned separately unless the quantity is too small, in which case it may be mixed with the grade 2 cream. When grading is first adopted at a creamery it may be necessary to churn these two grades together until the quantity of grade 1 cream reaches sufficient volume to be churned alone. Grade 3 cream should be churned alone or mixed with grade 2 cream. Grade 4 cream should never be mixed with cream of a high grade as it will reduce the entire quantity to fourth grade. Such cream should be rejected.

It may be advisable to build up a local market for high-grade butter. Make a churning from the best grade of cream and place this special butter in the refrigerator to be sold as fast as the trade demands it. Make another churning of special butter as soon as the supply is exhausted, or whenever it begins to lose some of its characteristic freshness.

Cream that meets the requirements of grade 1 can be made into butter that will score 92 or higher, provided the factory methods are on a sufficiently high standard. Butter on the market is scored 92 and higher only when the flavor is clean and fine. Slight carelessness on the part of the creamery operator, however, may cause the loss of one point in the score of the butter. Therefore, only the best methods of operation should be used from the time the cream is received until the butter is sent to market. All pumps, pipes, vats, and churns must be kept scrupulously clean to protect the cream from contamination. As the cream is received and run into the vat, it must be cooled to retard bacterial growth while the vat is being filled. It should be properly pasteurized as soon as possible, care being taken to avoid conditions that cause scorched or oily flavors, or mealy butter. The cooling of the cream, its temperature when churned, the temperature of the wash water, and the method of salting and working the butter must all receive careful attention. A first-class butter maker takes great pride in being able to control all these details and turn out butter of high quality.

FLAVOR CAUSED BY IMPROPER USE OF NEUTRALIZER

The defect that appeared the second largest number of times in these butter judgings was neutralizer flavor. Neutralization of cream for butter making refers to the addition of an alkaline substance to reduce the acidity. The presence of this defect indicates that the butter was made from cream so sour when delivered at the creamery that a neutralizer was used to standardize the acidity to a percentage that would permit pasteurization. The most effective way to prevent neutralizer flavor is to require that only sweet cream be delivered . Such cream does not have to be neutralized. At many creameries, however, some sour cream must be accepted and a neutralizer employed. Neutralizers, when properly used, do not impart an undesirable flavor to the butter, and where this defect appears the butter maker is solely responsible for its presence, as it is caused by improperly carrying out the process of acid standardization. The use of neutralizers is legal and applicable only in standardizing the acidity of wholesome cream. Neutralizers should not be used in an attempt to renovate cream that because of spoilage is unfit for food.

Neutralizer flavor in butter may be caused by: (1) Adding too much neutralizer to the cream, (2) dumping the diluted neutralizer mix into the cream instead of sprinkling it in slowly, (3) having the cream too warm when the diluted neutralizer mix is added, or (4) failing to dilute the concentrated neutralizer mix properly with water before adding it to the cream.

PROCEDURE FOR PROPER USE OF NEUTRALIZER

To prevent the occurrence of neutralizer flavor each step in the process of standardizing the acidity of the cream must be carried out correctly. These steps are as follows:

1. Prepare a neutralizer mix of known strength, using a pure, finely pulverized reagent.
2. Determine the acidity of the cream and the quantity of acid to be neutralized.
3. Calculate the quantity of neutralizer mix required.
4. Warm the cream to a temperature of from 85° to 100° F.
5. Dilute the neutralizer mix before adding it to the cream.
6. Add the diluted neutralizer mix slowly, in the form of a spray, while the cream is being stirred vigorously.

DETERMINING THE QUANTITY OF ACID TO BE NEUTRALIZED

For the correct acid standardization of a churning of sour cream it is essential to know the exact weight of the cream (including rinse water) in the vat, and the percentage of acid that the cream contains. In some creameries the weight of cream in the vat is readily obtained from the record of the weights of the various lots of cream that were emptied into it. To this sum is added the weight of any rinse water that may have been used, including the drip from steaming the cans, in draining them into the vat. If the quantity of cream (and added water) cannot be obtained in this way, a measuring stick graduated to indicate the weight of cream in the vat may be used, but this method is not so accurate.

In order to determine the percentage of acid in the cream it is essential that a representative sample be obtained. The cream in the vat should be warmed to about 85° F. and mixed thoroughly by running the coil for several minutes. Then a cupful should be dipped out and from this sample a measured volume or weight taken for the acid determination. If air has been whipped into the cream, or if the cream is yeasty or gassy, care should be exercised not to include foam or air bubbles in the material drawn into the pipette. If this cannot be avoided the material to be titrated should be weighed instead of measured.

Directions for making an acid determination are given on page 33.

PREPARING THE NEUTRALIZER MIX

In neutralizing cream for butter making, a calculated amount of an alkaline substance is added for the purpose of reducing the acidity of the cream to a predetermined point, usually 0.25 percent. It is evident that the neutralizing strength of the alkaline substance must be known accurately. There are several neutralizers in general use and they vary materially in strength.

Some of the more commonly used neutralizing agents, and the quantity of each required to neutralize 1 pound of lactic acid, are given in table 2.

TABLE 2.—*Neutralizing value of some neutralizing agents*

Alkali	Trade name	Chemical formula	Dry alkali required to neutralize 1 pound of lactic acid
			Pounds
Magnesium oxide	Magnesia lime	MgO	0.224
Magnesium hydroxide	Magnesium hydrate	$Mg(OH)_2$	.324
Calcium hydroxide	Slaked lime or lime hydrate	$Ca(OH)_2$	.411
Sodium bicarbonate	Baking soda	$NaHCO_3$	.933
Sodium carbonate	Soda ash	$Na_2CO_3H_2O$	.688
Sodium carbonate (crystals)	Sal soda	$Na_2CO_310\ H_2O$	1.588

The neutralizing agent used, as previously stated, must be made up into a stock solution or suspension, called neutralizer mix, which is diluted before it is added to the cream. The mix must be prepared accurately in order that a measured quantity, usually 1 pint or 1 quart, will neutralize 1 pound of lactic acid in the cream or reduce the acidity of 1,000 pounds of cream by 0.1 percent. It is customary to make up a concentrated mix containing about 20 percent of dry neutralizer. The concentrated mix should always be diluted before it is added to the cream.

It is advisable, especially in the case of lime neutralizers, to prepare enough mix at one time to last several days.

If hydrated lime (calcium hydrate) is used, the mix should be made of such strength that 1 quart will reduce the acidity of 1,000 pounds of cream by 0.1 percent. Table 2 shows that 0.411 pound of lime is required to neutralize 1 pound of lactic acid. All of the lime, however, is not available to neutralize acid, because lime has a great affinity for casein. For this reason it is necessary, when using lime neutralizers, to add about 20 percent more than the quantity required to neutralize the acid. Therefore, the mix should contain $0.411+(0.20\times0.411)=0.493$ pound of lime in each quart of mix, or 1.972 pounds of lime in a gallon, or approximately 19¾ pounds of lime in 10 gallons.

To make 10 gallons of lime mix pour about 5 gallons of cold water into a 10-gallon can, add 19¾ pounds of lime, and stir thoroughly until all lumps are broken up and an even emulsion is obtained. Then add sufficient water to fill the can, making 10 gallons of lime mix. Stir again and let stand for several hours before using. As the lime settles quickly, the mix must be stirred thoroughly each time that a portion is measured out for use in neutralizing cream. If care is not exercised in taking the required quantity of mix before agitation stops, the portions taken will vary in strength from time to time, and the acidity of the cream will not be correctly standardized.

CALCULATING THE QUANTITY OF NEUTRALIZER MIX REQUIRED

The amount of neutralizer mix required is readily calculated by the following method: For example, 2,240 pounds of cream containing 0.88 percent acid is to be standardized to 0.25 percent acid.

The required reduction in acidity will be 0.88−0.25, or 0.63 percent. As 1 quart of the lime mix will reduce the acidity of 1,000 pounds of cream by 0.1 percent the quantity required to reduce 2,240 pounds of cream by 0.63 percent is $2{,}240 \times 0.63 \div 100 = 14.1$ quarts.

Many neutralizers are sold under trade names and their chemical composition is not revealed. In such cases the manufacturer furnishes directions for making up the mix and a table showing the quantity required to reduce the percentage of acid in the cream to the desired standard.

ADDING THE NEUTRALIZER MIX TO THE CREAM

The cream should be warmed to a temperature of from 85° to 100° F. in order to increase its fluidity and thus aid in its rapid mixing with the neutralizing agent. The stock batch of mix should be stirred thoroughly, and the required number of pints or quarts of mix measured out while the stirring is continued. In order to remove any lumps from the portion taken for use, it should be passed through a well tinned wire screen of approximately 16 mesh. After the solution has been strained, it should be diluted with an equal volume of water, thoroughly stirred, and then sprinkled evenly and slowly over the surface of the cream while the coil or other stirring device is running. A convenient way to sprinkle the neutralizer is by using a garden sprinkling can. It is usually necessary, however, to enlarge the holes in the sprinkler head.

Another satisfactory device can be made by boring numerous small holes in the bottom of a metal trough shaped like a common eaves gutter. The trough should be as long as the vat and closed at both ends. Clamps or hooks are necessary to hold it in position over the cream vat. The neutralizing mixture when poured into the trough will be distributed the full length of the vat.

If the neutralizer mix is not sufficiently diluted before it is added to the cream, or is poured directly into the cream, some of the cream will be temporarily too strongly alkaline from an excess of neutralizer which will then impart its flavor to the butter.

CHECKING THE ACIDITY OF STANDARDIZED CREAM

The acidity of cream may be standardized to within a few hundredths of 1 percent, if a reliable neutralizing agent is used and proper care is exercised in all details of the work. As a check on the accuracy of the standardization, the acidity of the neutralized cream should be determined after it has been pasteurized and cooled. An accurate check cannot be made before this stage of the process, because the reduction of acidity is not complete until the cream has been pasteurized and cooled. An acidity determination made on the cream 15 to 30 minutes after the neutralizer has been added may result in a value which is as much as 0.1 percent higher than that of a determination made after the cream has been pasteurized and cooled.

From the foregoing it is evident that correct standardization of acidity can be accomplished only by adding the exact quantity of neutralizer required, as determined by a calculation based on the

original acidity of the cream and the strength of the neutralizer used. If the neutralized cream does not have the calculated acid content, it is evident that an error has been made in determining the original amount of acid in the cream or in the amount of neutralizer added, or because sufficient allowance was not made for the affinity of casein for the neutralizer. If, however, no error was made in the work, then the neutralizing agent may be off strength, and should be checked.

The neutralizing value of commercial lime, one of the reagents frequently used, depends upon the percentage of pure reagent it contains. Because low-grade lime was used, or for some other reason, a neutralizer mix made up according to a given formula may prove to be weak when the pasteurized cooled cream has been checked for acidity. If this happens, the degree of error should be noted, and a correction factor applied, so that in standardizing the acid content of subsequent batches of cream the correct quantity of neutralizer may be used.

The neutralizer mix can be checked in the following manner: Assume that the acidity of 2,000 pounds of cream is to be reduced from 0.90 percent to 0.25 percent. The quantity of lime mix of standard strength that will be required, according to the formula given under Calculating the Quantity of Neutralizer Mix Required, is $2{,}000\times(0.90-0.25)\div100$, or 13 quarts. After this quantity of lime mix has been added to the cream, and the neutralized cream has been pasteurized and cooled, if the acidity is then found to be 0.30 instead of 0.25 percent, the mix is evidently below standard strength. To reduce the acidity of 2,000 pounds of cream from 0.90 percent to 0.30 percent would require only 12 quarts of standard-strength mix $[2{,}000\times(0.90-0.30)\div100=12]$. If 13 quarts of substandard mix has the neutralizing strength of 12 quarts of standard mix, then $1\frac{1}{12}$ quarts of the substandard mix must be used for each quart of standard mix required. Therefore $1\frac{1}{12}\times13$, or $14\frac{1}{12}$ quarts of the substandard mix would be required. If it is certain that the weakness of this batch was due to low neutralizing value of the reagent, when the next batch of neutralizer mix is made up from the same package of reagent, instead of using $19\frac{3}{4}$ pounds of lime to make 10 gallons of mix, $1\frac{1}{12}\times19\frac{3}{4}$, or 21.4 pounds, should be used. One quart of mix will thus have the standard neutralizing strength. A check should be made on the neutralizing value of each new batch, barrel, or drum of neutralizer used.

DOUBLE NEUTRALIZATION

With cream of very high acid content (over 0.8 percent acid) so-called "double neutralization" may be found advantageous. By the term "double neutralization" is meant the use of the same neutralizer, or two different ones, in two successive applications at an interval of about 5 minutes. For example, the acidity of cream with an original acid content of 0.8 percent may be reduced to 0.4 percent by the addition of lime, and after a few minutes be still further reduced by the use of additional lime or one of the so-called soluble neutralizers. The quantity of each neutralizer to be used must be calculated from the original acidity of the cream.

Some butter makers place much faith in the use of a lime neutralizer followed by a soda neutralizer. It is doubtful, however, whether the reduction of the acid content with soda is more desirable than a similar reduction with lime. The addition of the alkali in two applications and, therefore, over a longer period of time, is beneficial. Some operators follow the practice of adding the neutralizer at several intervals. When lime is used, care is taken not to add enough at one time to cause a lime odor to rise from the cream.

OTHER OFF FLAVORS AND THEIR PREVENTION

A cooked flavor in cream and in the butter made from it is produced by exposing the cream to too high a temperature in pasteurization or to a high temperature for too long a time. In vat pasteurization of cream cooking is sometimes caused by starting to pasteurize with very hot water in the coil of the vat or by turning steam directly into the coil. This is especially true when the vat is partly filled and the coil is only partly submerged. When heating cream in a vat the water should be kept only about 20° warmer than the cream. If the cream is gradually heated in this way to a temperature of from 145° to 150° F., held for 30 minutes at this temperature, and then cooled, there should not be any cooked flavor in the butter. Neither should there be any trouble if the cream is heated to 160° F. in the same manner and held only 15 minutes. In flash heating, crowding the capacity of the machine or running cold cream directly through it may produce a cooked flavor. It is advisable to use some method of forewarning the cream before it is run into a flash heater.

Rancidity is a fault that develops gradually in butter. It is hastened by high temperatures. The use of good cream and low temperatures retards its development. Butter should not be allowed to warm up and become soft in the workroom, but should be removed directly to a cold, clean, dry room. In such a room the butter may be held at about 40° F. for a week or more without injury to the quality. For long storage periods the temperature should be kept below 0°.

PREVENTION OF DEFECTS IN BODY

LEAKY BUTTER

Butter is said to be leaky when moisture is loosely incorporated with the fat and large drops of water readily leak out. Leakiness does not occur when butter is worked until all the moisture is divided into minute droplets and thoroughly diffused throughout the butter. To accomplish this the butter must be of the proper firmness and plasticity when worked. This condition may be obtained by holding the cream at or below the churning temperature for at least 2 hours before churning, using a temperature that will require a churning period of about 45 minutes, and washing with water at a temperature that will cause the butter to remain at the proper degree of firmness. A good way to determine whether butter is sufficiently worked is to take a solid chunk of it on a paddle and with a second paddle cut off a piece vertically, and press the butter so that the cut surface

will show beads of water. When the butter is sufficiently worked the only moisture squeezed out will be in the form of a few tiny beads smaller than pinheads.

GUMMY BUTTER

The body of butter is directly affected by the feed of the cows. Using certain feeds, notably cottonseed meal, in excessive quantities results in butter of a high melting point and gummy body. A gummy body is intensified when butter is made from high-acid cream or when the butter is exposed to high temperatures. Not much is known about methods of preventing gumminess other than reducing the quantity of or omitting feeds that tend to produce it.

OVERWORKED BUTTER

Butter is said to be overworked when it shows a tendency to stick to a knife or trier and has a very dry, dull appearance instead of a waxy, bright one. Working butter longer than is required for proper incorporation of moisture and salt results in overworked butter. An overworked condition, however, may be produced by factors other than too many revolutions of the churn. When the melting point of the butterfat is high and the fat globules are small, the butter granules are likely to be too firm and dry, and an overworked condition may occur before the desired amount of moisture can be incorporated. To overcome this the churning temperature should be high enough to cause the butter granules to be moderately firm.

In general it is very helpful to have an automatic counter on the churn that records the number of revolutions or a conveniently placed clock, so that the working time may be observed from places where other work is carried on. The operator can save much time and obtain better results by a definite plan of procedure.

MEALY BUTTER

A mealy texture in butter is usually caused by crystallization of butterfat that has melted or "oiled off" from the cream. Oiling off is likely to be caused by heating or cooling cream too slowly between the temperatures of 112° and 70° F. or by quickly heating cream that is very thick or frozen.

Mealy texture may also be caused by improper acid standardization of high-acid cream.

COLOR DEFECTS AND THEIR PREVENTION

While a wide variation in the intensity of color is permitted by judges of butter because of market demands, it should be remembered that the butter manufacturer has a great deal of influence in shaping the demand for butter of a certain color. This is especially true in undeveloped markets. Very little discrimination against color variations is found in southern markets. Since it is to the interest of the dairy industry to have a distinctive yellow color in butter an effort should be made to maintain, throughout the year,

the attractive shade of yellow that is naturally imparted to butter when cows are on pasture. Furthermore, it is necessary to maintain this shade in order to have a uniform color in the butter throughout the year. Uniformity in color, like uniformity in other qualities of the butter, is important. The amount of coloring agent to add can be determined accurately by basing it on the pounds of butterfat in the cream. No set rule can be given because such factors as breed of cattle, feed, and season of the year influence the quantity required. Directions on the package of coloring agent are helpful. In the absence of directions about 25 cubic centimeters of coloring agent to 100 pounds of butterfat should be used in late fall and winter and the amount varied until the desired shade is obtained. Color standards can be obtained from butter-color manufacturers and dairy-supply houses. If, for any reason, the coloring agent is not added to the cream before churning, it may be mixed thoroughly with the salt added to the butter.

Curd specks are likely to occur in butter made from very sour cream of low fat content, or may be produced by heating sour cream to too high a temperature before adding neutralizer. Cream with an acidity of 0.3 percent or more is very likely to curdle when it is brought up to the pasteurizing temperature. Hence, correct standardization of the acidity before pasteurization is necessary. When difficulty is encountered in preventing the appearance of curd specks, it is good practice in pasteurizing the cream to pass it through a filter when the temperature reaches 120° F. and then finish the pasteurizing. Several types of filters with large capacity are available. In another method the cream is circulated by pumping it from the outlet of the vat into a strainer on the top of the vat while it is being pasteurized and again while it is being cooled down to about 120°. This method will remove practically all curd specks.

Mottled and wavy color in butter is caused by an uneven distribution of salt, moisture, and curd. If the salt is scattered evenly over the butter from end to end of the churn, and the butter is worked according to the directions given under Leaky Butter, there should be no trouble from mottles or waviness.

CONTROLLING THE COMPOSITION OF BUTTER

BUTTERFAT AND MOISTURE CONTENT

A minimum requirement of 80 percent of butterfat in butter has been established by law for the protection of the consumer and the good of the butter industry. While it is necessary that the manufacturer keep the butterfat content of his butter at not less than 80 percent, it is also necessary that he avoid an excessive butterfat content in order to prevent financial loss. A standard of 80 to 80.9 percent butterfat is generally used as a working limit by most butter manufacturers, and should be established and maintained by every creamery operator. Much deviation from the standard selected shows careless workmanship.

In the Alabama educational butter judgings the samples ranged from 75.4 to 87.4 percent in butterfat content. Only 23.3 percent of the samples were between the recommended standard of 80 to 80.9

percent. It is evident that some of these creameries are liable to be involved in legal difficulties because of the low butterfat content of their butter, and others are likely to be involved in financial difficulties because of the high cost of their butter due to its excessive butterfat content.

To what extent uniformity in composition of butter can be maintained is illustrated by the following record of 20 consecutive churnings made at a creamery on a contract with the United States Navy Department. The specifications required that the butter contain at least 80 percent of butterfat, not over 15.5 percent of water, and from 2 to 3 percent of salt. The determinations on butterfat, moisture, and salt were made by an inspector working under the supervision of the Bureau of Dairy Industry, United States Department of Agriculture. None of the 20 samples had less than 80 percent butterfat. Only 1 was below 80.5 percent, and all the rest were within 1 percent of 80.5 percent. The moisture content ranged from 15 to 15.4 percent or less than one half point from the standard, and the salt content from 2.30 to 2.85 percent.

TABLE 3.—*Analyses of 20 consecutive churnings of butter at one creamery*

Churning no.	Butterfat	Moisture	Salt	Churning no.	Butterfat	Moisture	Salt
	Percent	*Percent*	*Percent*		*Percent*	*Percent*	*Percent*
1	80.80	15.3	2.60	11	80.90	15.4	2.70
2	80.10	15.3	2.85	12	80.80	15.3	2.80
3	81.50	15.3	2.20	13	80.90	15.2	2.70
4	81.00	15.3	2.70	14	81.50	15.1	2.30
5	80.80	15.2	2.70	15	81.10	15.1	2.60
6	80.75	15.4	2.65	16	81.20	15.0	2.70
7	81.00	15.2	2.70	17	80.90	15.2	2.70
8	81.20	15.3	2.30	18	80.90	15.3	2.80
9	80.90	15.2	2.80	19	80.90	15.1	2.65
10	80.90	15.3	2.70	20	80.90	15.2	2.60

Many creameries have adopted the following as their standard composition of butter: Butterfat, 80.5 percent; moisture, 15.9 percent; salt, 2.8 percent; curd, 0.8 percent.

The fat content of the butter is controlled mainly by regulating the amount of water incorporated in the butter. The percentage of salt in the butter must be adjusted to suit the market demands. Medium salted butter contains between 2 and 3 percent of salt. The percentage of curd (which includes lactose and ash) is kept as low as possible, and usually totals somewhat less than 1 percent. The percentage of moisture in butter with the best body and texture usually is not so great as to cause the percentage of fat to be less than 80. It is possible to regulate the conditions of manufacture so that when the butter is ready for its final working it will be of the proper firmness and the amount of moisture in the churn will be such that the finished butter will be of the desired composition.

PREVENTING THE INCORPORATION OF EXCESSIVE MOISTURE

When there is a tendency for the butter to hold too much moisture, it can be overcome by adjusting the manufacturing process. The following steps usually are effective in producing butter that is relatively low in moisture content:

(1) The cream should be held at a temperature of not to exceed 40° F. for at least 3 hours immediately before churning, and then warmed slowly to churning temperature.

(2) The cream should be churned at a temperature that will bring the butter in firm granules. This usually requires a churning period of 50 to 60 minutes. The churn should be stopped when the butter granules are approximately the size of kernels of wheat or corn.

(3) The wash water should be slightly colder than the buttermilk, or cold enough to keep the butter granules firm.

(4) After the butter has been washed and drained, it should be worked several revolutions to remove any excess water. After each revolution the churn should be stopped to drain off the water.

(5) A moisture determination should then be made. If the percentage of moisture is satisfactory the butter should be trenched, dry salted, the trench closed, and the butter worked until all free moisture is incorporated. If the moisture content of the unsalted butter is found to be too low, a definite quantity of water should be added with the salt, as explained in the following paragraphs.

INCREASING THE MOISTURE CONTENT TO THE DESIRED PERCENTAGE

If difficulty is encountered from the butter having too low a moisture content, the churning and washing temperatures should be raised slightly, but should never be high enough to cause a soft, slushy consistency of the butter granules. If the granules are only moderately firm, they will readily take up additional moisture during the working process. When it is desirable to add water in working the butter, this should not be done until after the butter has been partly worked, and a preliminary moisture determination should be made at this stage. From the quantity of partly worked butter in the churn and the percentage of moisture in it, the quantity of water present in the partly finished butter is calculated. This quantity of water is subtracted from the total amount of water that the finished butter should contain, and enough water to make up the difference is added to the contents of the churn (fig. 2), together with the required amount of salt, and then the working of the butter is completed. The method of calculating the amount of water to add is illustrated by the following example:

Butterfat in the cream	pounds	632.0
Required composition of the butter:		
Butterfat	percent	80.5
Moisture	do	15.9
Salt	do	2.8
Curd	do	.8
Total amount of butter to be made (fig. 8) (632÷80.5×100)	pounds	785.09
Churn and partly work the butter.		
Preliminary moisture determination on the partly worked butter	percent	12.9
Weight of curd (0.8×785.09)	pounds	6.28
Weight of butterfat plus curd (632+6.28)	do	638.28
Percentage of butterfat and curd in partly worked butter (100—12.9)	percent	87.1
Total quantity of unsalted, partly worked butter (638.28÷87.1×100)	pounds	732.81
Water required in the finished butter (0.159×785.09)	do	124.83
Water present in the unfinished butter (0.129×732.81)	pounds	94.53
Water to be added (124.83—94.53)	do	30.30

If the butter had been salted before the preliminary moisture determination was made, and 12.9 percent moisture obtained, then the calculations would be as follows:

Salt added (785.09×0.028)—pounds—	21.98
Weight of butterfat, curd, and salt (632+6.28+21.98) pounds—	660.26
Percentage of butterfat, curd, and salt in the unfinished butter (100—12.9)—percent—	87.1
Total quantity of unfinished butter (660.26÷87.1×100) pounds—	758.05
Water required in the finished butter (15.9×785.09÷100) pounds—	124.83
Water present in the unfinished butter (12.9×758.05÷100) pounds—	97.79
Water to be added and incorporated in the butter (124.83—97.79)—pounds—	27.04

In finding the amount of moisture to be added to the partly worked butter, the mistake is often made of multiplying the total weight of the finished butter by the difference between the percentage of moisture found in the partly finished butter and the percentage desired in the finished butter, In the preceding example, the difference between the moisture present and the total content desired amounts to 15.9−12.9, or 3 percent; whence 0.03×785.09= 23.55. This figure would be 6.75 pounds short (30.30−23.55) if the butter had not been salted before the preliminary moisture test, and it would be 3.49 pounds short (27.04−23.55) if the salt had been added.

It must be remembered that on account of unavoidable losses the figures used are never absolutely correct, and the error may be increased by careless methods. It is evident, therefore, that the butter maker must check the finished product to determine whether he is getting the results desired. If the results are not satisfactory, the operator should systematize his methods and apply modifications wherever necessary so that the butter will have the required composition.

SALTING

Scattering the salt very unevenly over the butter, or oversalting the butter to such an extent that there is not enough water present to dissolve all the salt, will result in a gritty condition from particles of undissolved salt. In each case the defect is intensified by insufficient working. Very rarely grittiness may be caused by fine sand where the wash water is pumped out of a well.

In order to obtain the proper percentage and distribution of salt in the butter and to avoid great variations in salt content from one churning to another, it is necessary to use a definite method of salting. As the salt dissolves in the water, and not in the butterfat, it is evident that if the salt added is to be properly incorporated in the butter, all the water in the churn when the salt is added must be evenly and completely incorporated in the butter. Therefore, it is desirable to have the right amount of water in the churn at the time of salting, as an excess causes loss of salt. To calculate the required amount of salt for a churning of butter it is necessary to determine as nearly as possible the amount of finished butter that will be produced from a churning of cream with a given amount of butterfat. Assuming that butter with 80.5 percent of fat and 2.8 percent of salt is to be made, the calculation will be as follows:

100 pounds of fat will make $100 \div 80.5 \times 100 = 124.22$ pounds of butter. Then $124.2 \div 100 \times 2.8 = 3.47$ pounds of salt, which is the amount that must be homogeneously incorporated with 100 pounds of fat to obtain 2.8 percent salt in the butter.

The quantity of salt (assuming none of it is lost during incorporation) for any given amount of fat in the churning when butter with 80.5 percent of fat is to be made can be determined quickly by referring to the scales on page 17.

RAPID CALCULATIONS OF BUTTER COMPOSITION

The determination of the correct amounts of the different ingredients to go into butter of a definite composition, requires careful calculations. These calculations take considerable time, and often must be made when the butter maker is crowded with other work. The several calculations required for each churning of butter and the rush of work also, lead to mistakes. The accompanying scales in figures 1 to 8 were devised as a means of saving time and avoiding errors.

In using these scales it must be remembered that they are based on a definite standard of 80.5 percent of butterfat in the finished butter. The figures in each scale are based on the number of pounds of butterfat that goes into a churning.

The scales in figure 1 are for determining the number of pounds of salt to use with a given number of pounds of butterfat to get the required percentage of salt in the finished butter. For example, if there are 750 pounds of butterfat in a churning and the butter is to contain 2.8 percent of salt, then on the scale for butter with 2.8 percent salt, find the 750-pound fat mark on the left. At the point directly opposite this 750-pound mark, read the number of pounds of salt (slightly more than 26.1 pounds) to be put into this churning to get 2.8 percent of salt in the finished butter.

The scales in figures 2 and 3 are for use in determining the number of pounds of water to add to partly worked, unsalted butter when the preliminary moisture determination shows a deficiency in percentage of moisture, to obtain 15.9 percent moisture in finished butter containing 80.5 percent of butterfat. At the top of the scales are shown the percentages of moisture in the unfinished, unsalted butter in intervals of 0.5 percent, ranging from 11.5 to 13.5 percent in figure 2, and from 14 to 16 percent in figure 3. The left side of each scale shows the number of pounds of butterfat and the right side shows the number of pounds of water to add.

Usually the preliminary moisture determination is made after the partly worked butter has been salted. The scales in figures 4 to 7 are used for determining the quantity of water to add, when the percentage of moisture in the unfinished, salted butter is too low to produce butter with 15.9 percent of moisture. The scales shown in figures 4 to 7 cover percentages of moisture in the unfinished, salted butter ranging from 12 to 15.8 percent.

In using these scales the quantity of water to add is determined as follows: Assume that the unsalted butter has a moisture content, as shown by the preliminary determination, of 13 percent, and that the weight of the butterfat in the churn is 750 pounds, as in the example for calculating the salt. In figure 2 follow the scale for 13

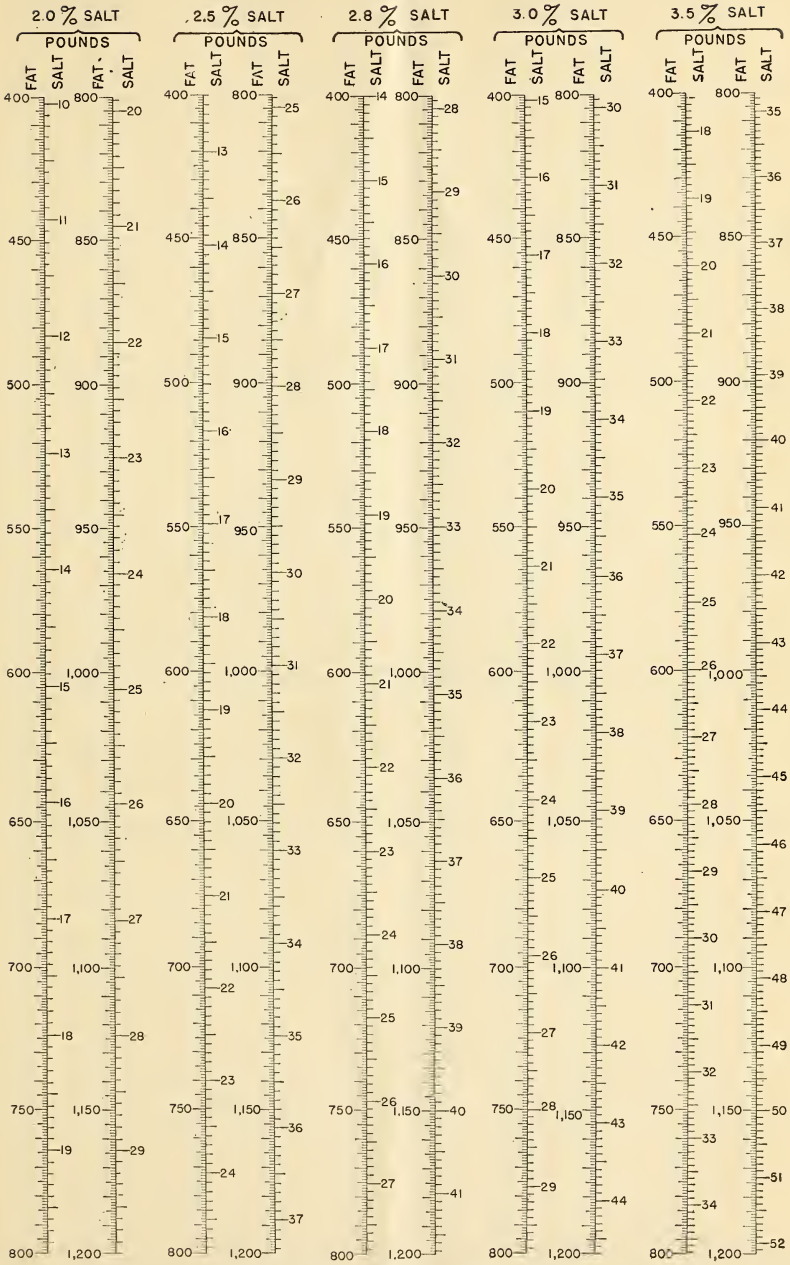

FIGURE 1.—Scales for determining weight of salt to use with a given quantity of butterfat; the butter to contain 80.5 percent of butterfat and from 2 to 3.5 percent of salt.

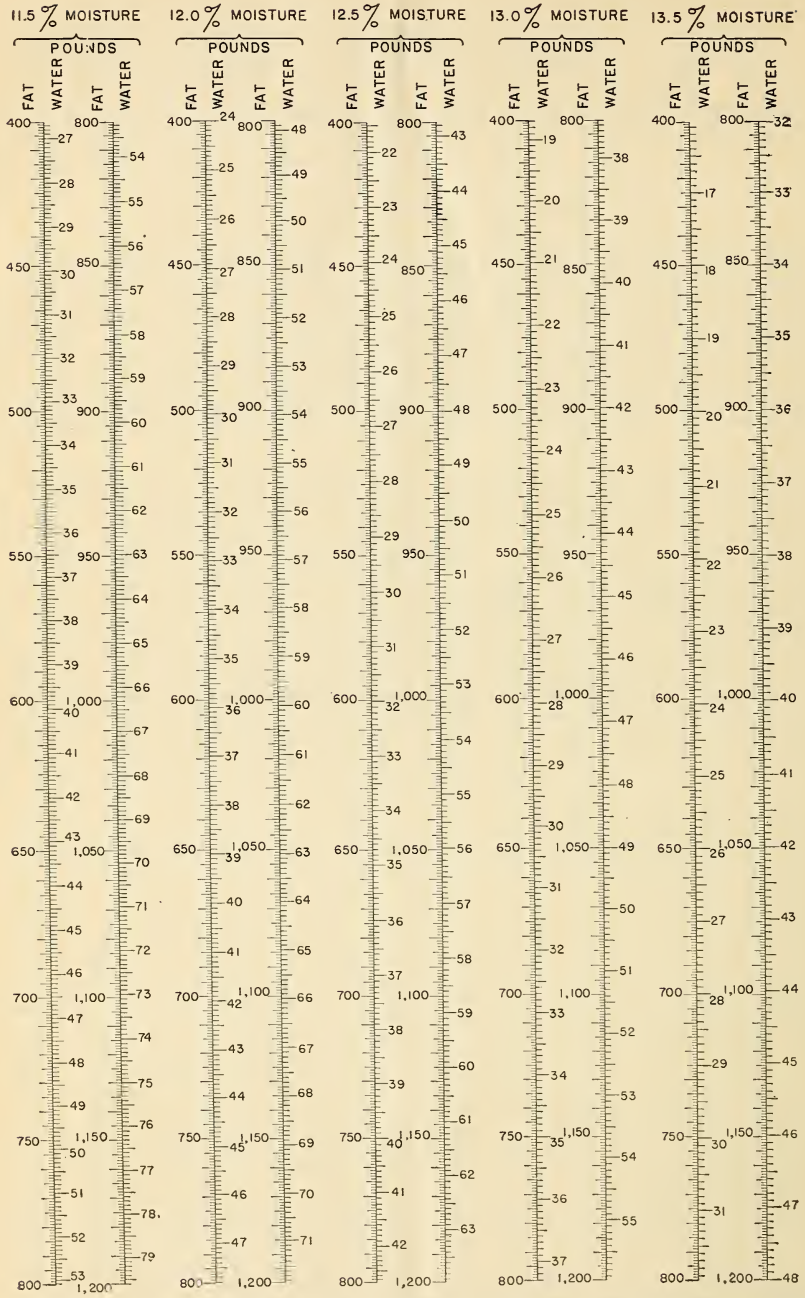

FIGURE 2.—Scales for determining weight of water to add before salting to partly worked butter containing 11.5 to 13.5 percent of moisture. Based on weight of butterfat in the churning. Percentage composition of the finished butter: Butterfat, 80.5; moisture, 15.9; salt, 2.8; curd, 0.8.

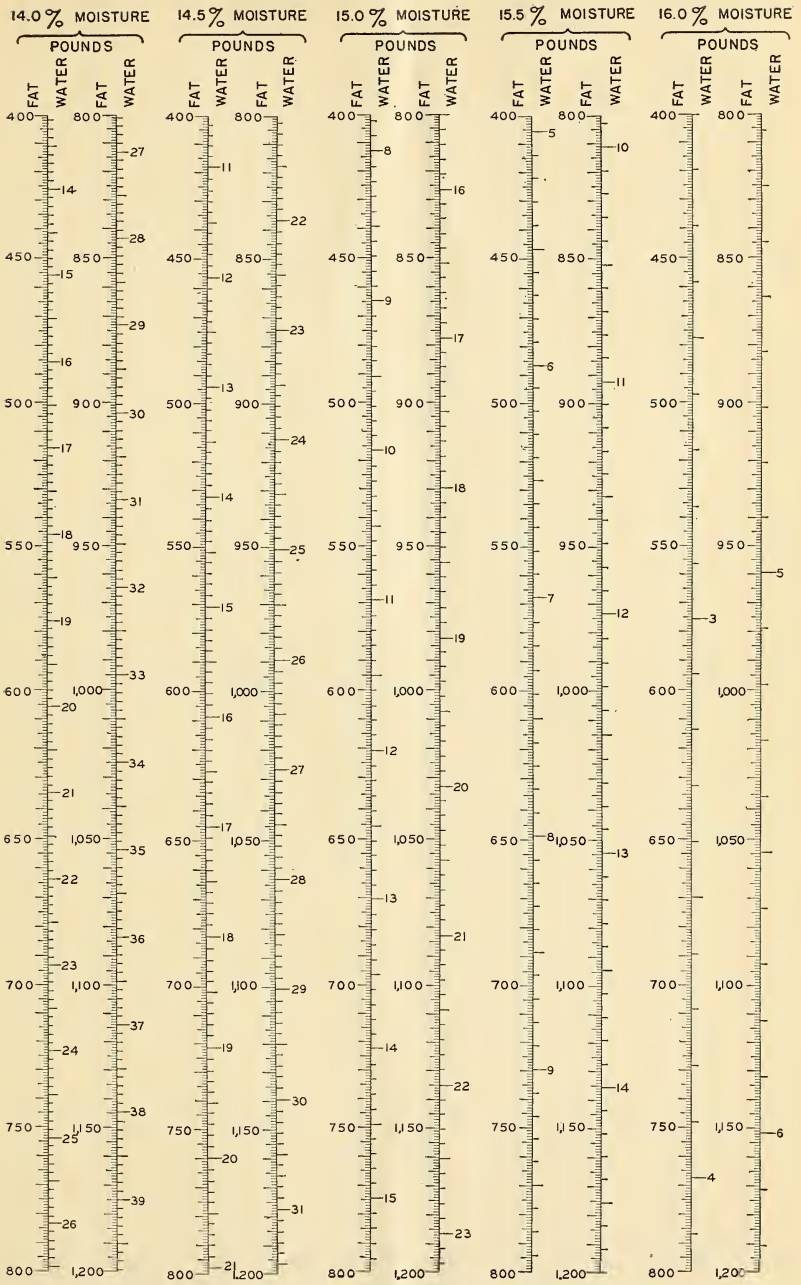

FIGURE 3.—Scales for determining weight of water to add before salting to partly worked butter containing 14 to 16 percent of moisture. Based on weight of butterfat in the churning. Percentage composition of the finished butter: Butterfat, 80.5; moisture, 15.9; salt, 2.8; curd, 0.8.

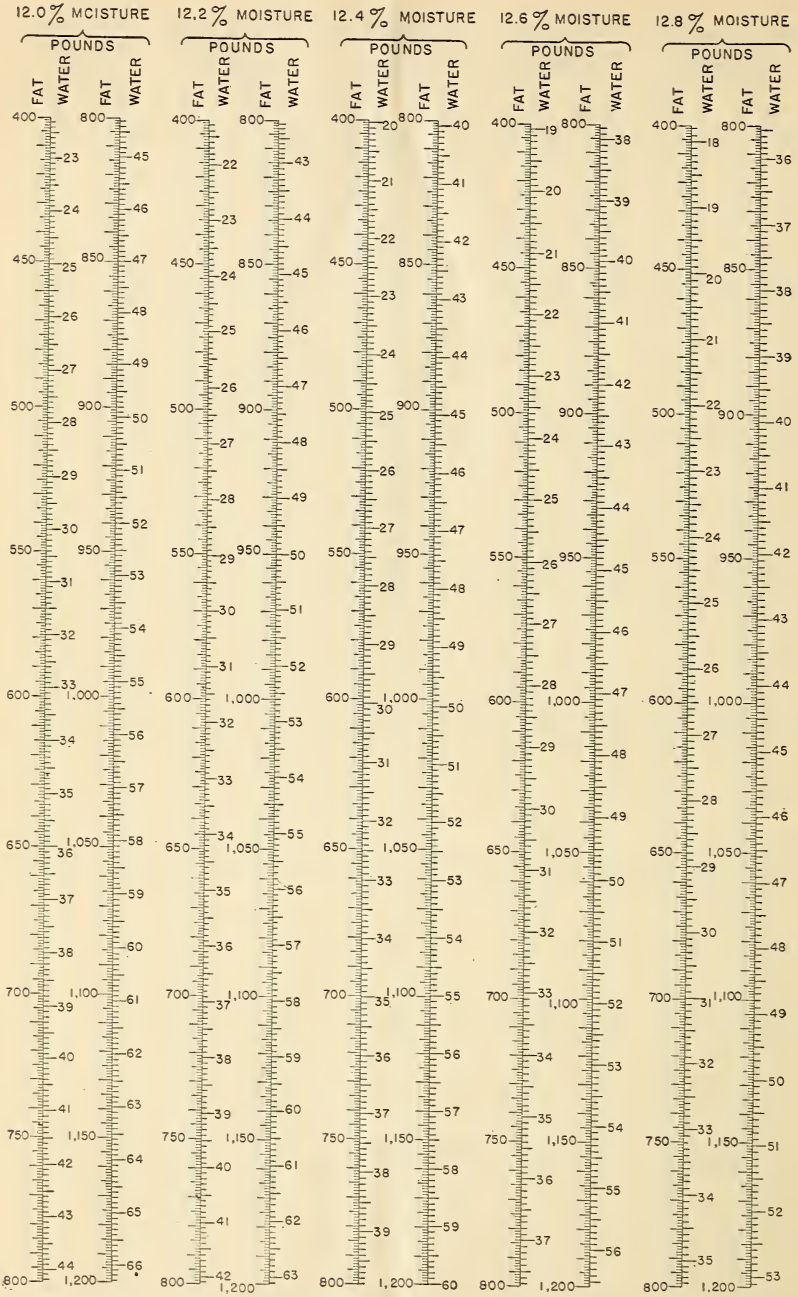

FIGURE 4.—Scales for determining weight of water to add to partly worked salted butter containing 12 to 12.8 percent of moisture. Based on weight of butterfat in the churning. Percentage composition of the finished butter: Butterfat, 80.5; moisture, 15.9; salt, 2.8; curd, 0.8.

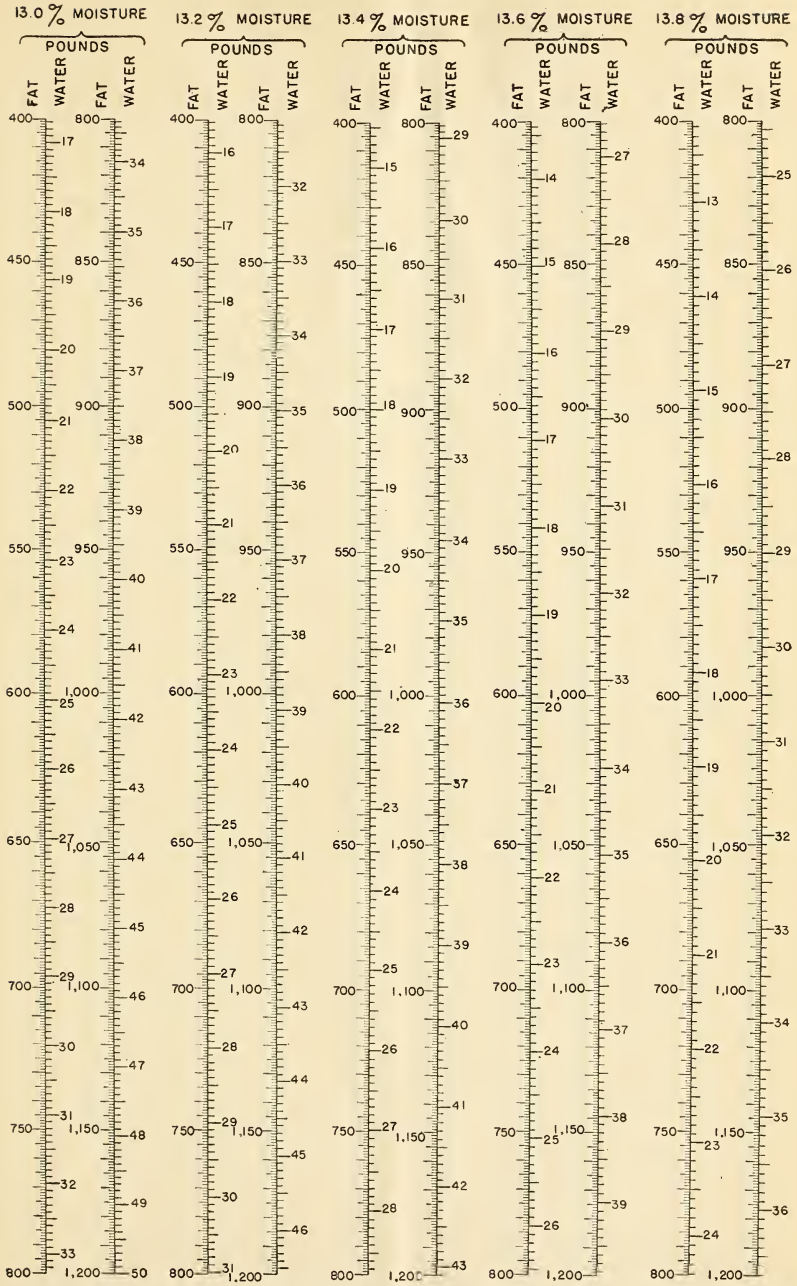

FIGURE 5.—Scales for determining weight of water to add to partly worked salted butter containing 13 to 13.8 percent of moisture. Based on weight of butterfat in the churning. Percentage composition of the finished butter: Butterfat, 80.5; moisture, 15.9; salt, 2.8; curd, 0.8.

FIGURE 6.—Scales for determining weight of water to add to partly worked salted butter containing 14 to 14.8 percent of moisture. Based on weight of butterfat in the churning. Percentage composition of the finished butter: Butterfat, 80.5; moisture, 15.9; salt, 2.8; curd, 0.8.

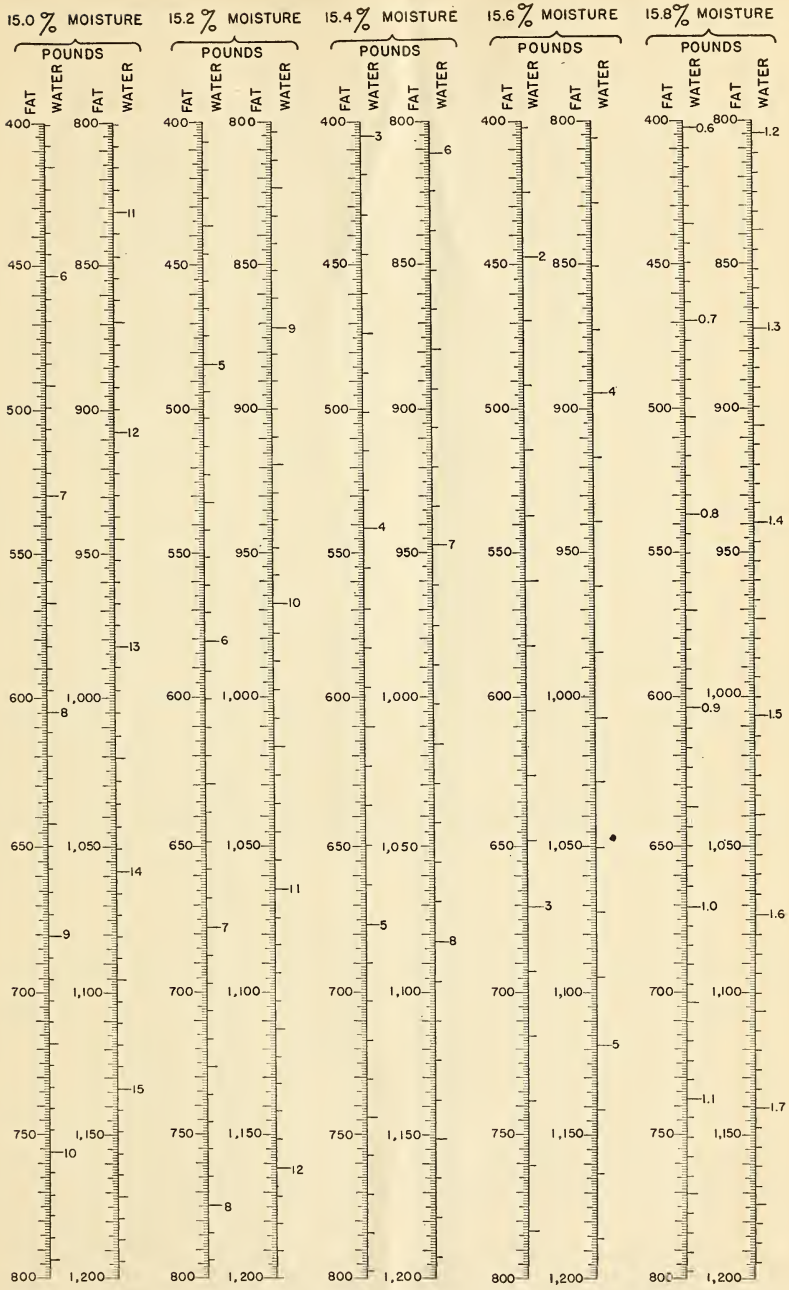

FIGURE 7.—Scales for determining weight of water to add to partly worked salted butter containing 15.0 to 15.8 percent moisture. Based on weight of butterfat in the churning. Percentage composition of the finished butter: Butterfat, 80.5; moisture, 15.9; salt, 2.8; curd, 0.8.

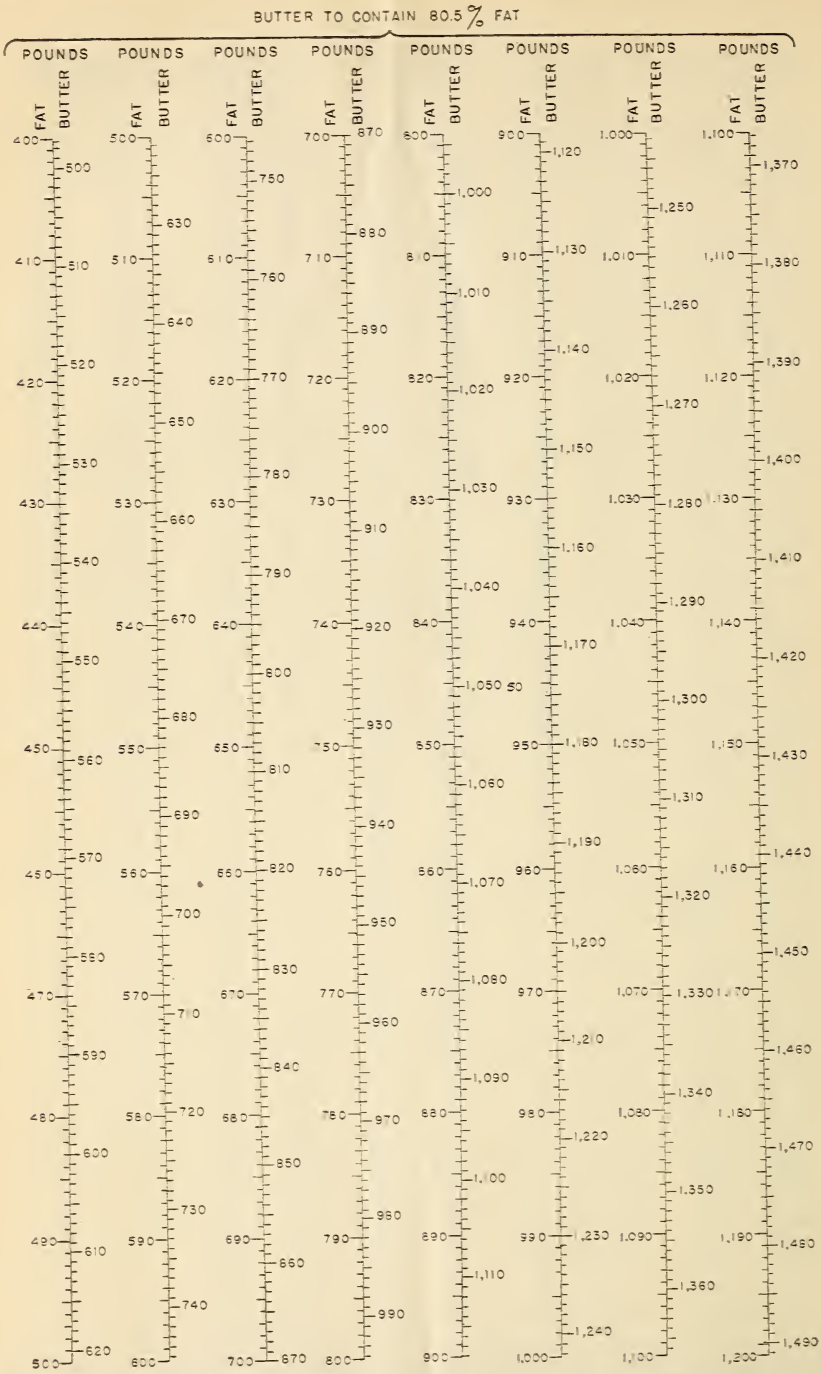

FIGURE 8.—Scale for determining weight of butter that should be produced from a given quantity of butterfat. Percentage composition of the butter: Butterfat, 80.5; moisture, 15.9; salt, 2.8; curd, 0.8. Close adherence to this composition will avoid needless loss and still keep the butter above the minimum requirement of 80 percent of butterfat.

percent moisture to the 750-pound butterfat mark, and directly opposite this mark, read the number of pounds of water to be added (35 pounds) to obtain 15.9 percent of moisture in the finished butter. If the butter has been salted, in figure 5 follow the scale for 13 percent moisture to the 750-pound butterfat mark, and directly opposite this mark, read the number of pounds of water to be added (31.2 pounds) to obtain 15.9 percent of moisture in the finished butter.

As the various percentages of moisture and salt which are shown in all these scales are expressed in uniform intervals, the approximate number of pounds for any intermediate percentage not shown by any one scale can be found easily from the corresponding figures on the two scales between which the required percentage falls.

In figures 4 to 7 for determining the amount of water to add to unfinished, salted butter, the scales are arranged in intervals of 0.2 percent and intermediate readings may easily be made.

The number of pounds of butter which will be produced from a given number of pounds of butterfat when the percentage of butterfat in the butter is 80.5 is shown in figure 8. For example, if 750 pounds of butterfat has been used in a churning, find the mark for 750 pounds of butterfat on the scale and opposite this mark read the number of pounds of butter, which in this case is 931.7 pounds. A butter yield appreciably higher than is shown on this scale would indicate a deficiency in fat content of the butter. The fat content of the butter should be held as near the working standard as possible.

Figure 8 can be used also to check up errors in workmanship by comparing the number of pounds of finished butter obtained from a given churning with the amount that should have been obtained from the number of pounds of butterfat as indicated by the scale. For example, if 500 pounds of butterfat produced 621 pounds of butter, and the fat determination of the butter showed 80.5 percent, this would show the work had been done accurately; but if a smaller or greater amount of butter was obtained with 80.5 percent of butterfat, this would show that an error had been made at some place in the operation.

GENERAL METHOD OF OPERATION

No formula can be devised for an absolutely accurate determination of all the various factors involved in the manufacture of butter. The operator must use his judgment as to the best procedure, and check his calculations carefully until he obtains the desired results.

The number of pounds of butterfat in the cream in the vat is usually slightly greater than that shown by the records, because in weighing the cream and determining its butterfat content small fractions are dropped in recording the amounts. The number of pounds of butterfat in the butter, however, is always slightly less than the number of pounds in the cream because of losses in handling and churning the cream.

Each operator can make various modifications in operating methods to suit conditions in his own plant, yet in controlling the composition of butter certain practices should be observed, and the following are submitted as a guide:

Hold the cream at or below churning temperature for at least 2 hours before churning.

Use a churning temperature that will bring the butter in about 45 minutes, churned to granules about the size of large kernels of wheat or corn.

Use wash water which is of about the same temperature as that of the buttermilk. In cold weather the wash water may have to be a little warmer, and in hot weather, a little colder than the buttermilk. Regulate this temperature so that the butter granules will be neither hard nor slushy, but in a firm, plastic condition that will allow suitable working.

In washing the butter, after draining off the buttermilk, first sprinkle about 20 gallons of water over the granules and let it drain off, then run into the churn nearly as much wash water as there was buttermilk.

Revolve the churn 3 or 4 times in high speed and drain off the water.

When the churn is thoroughly drained, scatter the required amount of salt over the butter granules. Then with the doors and drain tightly closed work the butter until practically all of the unincorporated water has been taken up.

Make a preliminary moisture determination.

If the moisture content of the unfinished butter is too high, fasten the doors so as to leave a crack of about one quarter inch and turn the churn until the doors are at the lowest point, then stop the churn to drain off any free water. Work the butter several revolutions of the churn, but after each revolution stop the churn with the doors at the lowest position. After a few revolutions, make another moisture determination. If the percentage of moisture is satisfactory, close the doors and work the butter until all moisture is well incorporated, as described under Leaky Butter. A method should be adopted that will avoid draining water after the butter has been salted, as this causes waste of salt.

If the moisture content is too low, calculate the amount of water required to bring the moisture up to the desired point. After adding the calculated amount of water, work again until all the water in the churn is thoroughly incorporated in the butter.

As a final check, determine the percentage of both butterfat and moisture.

PLANT PRACTICES TO PREVENT LOSSES OF BUTTERFAT

The numerous practices in a creamery require a trained operator who has the skill and ingenuity to meet each condition encountered. A short course in creamery operation at some agricultural college is an important factor in the training of an operator (fig. 9). Not only is such a short course important for the apprentice but the man who has assumed the duties of a qualified creamery operator will also be benefited by an occasional visit to a creamerymen's short course. The training can at all times be helped by reading some trade paper and two or more of these magazines are a valuable help to the man who is alert in his attention to plant practices. Some of these practices have a direct money value, and others have an indirect influence on the business, but each has a value in the satisfaction afforded by having a piece of work well done.

MAINTAINING THE OVERRUN

In efficiently operated creameries the quantity of butter manufactured is approximately 23 percent greater than the quantity of butterfat in the cream from which the butter was made. This increase in quantity of butter over butterfat is known as overrun. Maintaining the proper amount of overrun has a direct bearing on the financial success of the creamery. With an overrun of 23 percent, 123 pounds of butter are produced from 100 pounds of butterfat. However, the average overrun in a poorly operated creamery may be only 18 percent, representing a decrease of 5 pounds of butter on each 100 pounds of butterfat. In a creamery making 300,000 pounds of butterfat into butter annually, an overrun of only 18 percent

would represent a loss of 15,000 pounds of butter or approximately $4,000 in one year, on the basis of the 1931 average price of 27.05 cents a pound for 92-score butter on the Chicago market.

In order to maintain the overrun at about 23 percent the weighing and testing of the cream must be done accurately, losses of

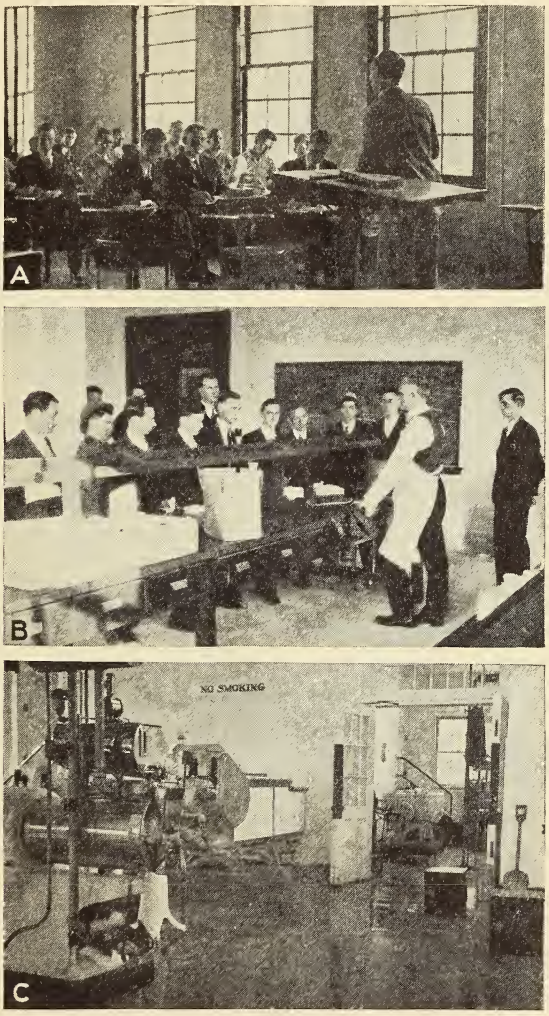

FIGURE 9.—Short courses in dairy manufacturing have a very decided influence on creamery development: A, Short-course class in lecture room; B, class in the laboratory; C, well-equipped factory for dairy-manufacturing demonstrations.

butterfat in the creamery must be held at a minimum, and the butterfat content of the butter must be closely controlled.

LOSSES AFFECTING THE OVERRUN

Table 4 shows the principal causes of loss of butterfat in handling cream and in making and handling butter, the normal losses found

in well-operated creameries, larger losses found in some creameries, the extremely high losses observed in a few creameries, and the possible total effect of all these various losses on overrun. In considering the itemized losses shown in the columns headed Frequent loss and Extreme loss it is not to be understood that losses of these magnitudes were all sustained in any one plant, but they were found at certain times and places in different plants, and whenever they are present will increase the error in calculating the amount of butter that will be produced.

TABLE 4.—*Possible losses of butter in receiving and processing 500 pounds of butterfat in cream from 100 patrons*

Source of loss of butterfat	Loss of butterfat in terms of butter		
	Normal losses	Frequent losses	Extreme losses
	Pounds	*Pounds*	*Pounds*
Farmers' delivery cans	0.00	0.50	1.00
Weigh can	.06	.50	1.00
Sample jars	.05	1.65	2.00
Test bottles	.70	.70	.70
Spilling cream in taking samples	.03	.50	1.00
Vat strainer	.18	1.00	2.00
Coils and sides of vat	.50	1.00	2.00
Rinsings in vat	.16	1.82	3.00
Pumps and pipes	.03	.33	1.00
Churn strainer	.05	1.00	2.00
Leaks in machinery	.04	.75	2.00
Fat in buttermilk	5.30	8.00	11.00
Butter sticking to inside of churn	.30	3.00	13.00
Butter sticking to ceiling overhead	0.00	.10	.20
Boxes and tubs	.04	.62	1.00
Printing machine	.03	.50	.62
Wrapping	.02	.50	.75
Scraps	.01	.25	.43
Total	7.50	22.72	44.70
Possible overrun	[1] 23.50	[1] 20.456	[1] 16.06

[1] Percent by weight that the quantity of butter produced exceeds the quantity of butterfat in the cream.

Some of these losses are avoidable, and others can be reduced to a minimum by care in operation. No attempt will be made to discuss in detail all of the operations that may cause loss of butterfat, but the following example of plant practices can be given.

WASHING THE CHURN

The method of washing the churn is a good example of direct savings. Washing the churn properly is a simple procedure. Immediately after removal of the butter, rinse the churn with about 25 gallons of water at 130° F. In the second rinsing use the same amount of water at 130°, and add about 1 pint of a good dairy washing powder. In the third washing use at least 30 gallons of water at 212° (boiling hot) and run the churn 4 minutes. Open the doors and turn the openings down, letting the water out quickly. After a few minutes, turn the churn so that the openings are on top again, and let it stand with the doors wide open, so that it can dry while still hot.

This procedure is simple enough, but failure to follow it closely will result in butter sticking to the churn, which is a common trouble

in southern creameries and a cause of much loss of butterfat. In fact, waste of butter from this cause constitutes one of the greatest losses, as shown in table 4, while it should be one of the minor losses when the churn is washed properly.

UPKEEP OF PLANT

The above example of savings from good practices can be carried further by considering the general upkeep of the churn (fig. 10) and the rest of the plant. For instance, the cork in the door frames of the churn or the packing in the bearings wears out, the paint becomes discolored, the driving parts show wear, and other things give out. All these need attention, and it is good plant practice to make an inspection at definite times to see that defects are corrected.

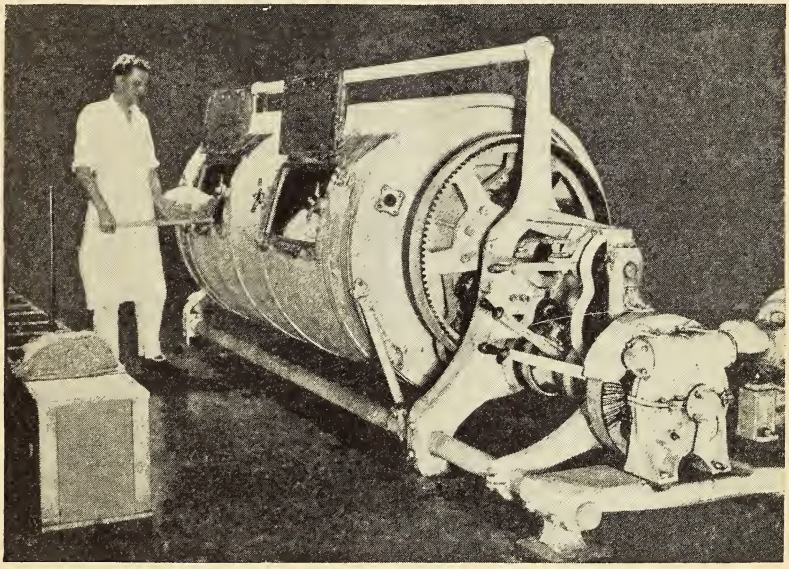

FIGURE 10.—A well-painted, clean, neatly kept churn is essential for sanitary handling of butter.

Such attention lengthens the life of the machinery and appreciably reduces manufacturing expenses. It is not only in the churn that the application of paint will brighten and preserve the surface, but in many other places in the plant. Places that become soiled can be washed and cleaned, but frequently the neatness of the plant cannot be restored without the use of paint.

All parts of the creamery should be kept in order and clean. The storeroom is a place often neglected. Here some suitable devices will help materially not only in keeping the place neat, but in actually preventing losses. Personal habits may easily drift into the practice of letting things lie where they drop, even though it is easier to put them in their proper location. Useful articles dropped promiscuously on the floor constitute one of the most noticeable eyesores in a creamery. A clean, neat floor throughout the creamery has an important influence on appearance.

To carry out these plant practices requires personal self training not only to see what is needed but to acquire habits that will keep the plant in a good working condition, as well as neat and attractive, a condition that the consumer has a right to expect where so delicate a food product as butter is handled.

METHODS OF ANALYSIS

In all work in connection with the determination of the quantity of butterfat or other substances in milk or its products it is of the utmost importance that a representative sample be taken. The cream in the can should be thoroughly mixed with an agitator before being sampled for determination of butterfat, and the sample should be taken immediately after the stirring is completed. If thin cream is allowed to stand only a very short time, a top layer will form that is richer in butterfat than the cream in the bottom of the can. Thick and lumpy cream usually requires vigorous agitation to reduce it to a uniform consistency, so that a fair sample can be obtained. Occasionally old lumpy cream may be received which is so difficult to mix that it becomes necessary to teach the patron the proper care of his cream in order that a representative sample may be obtained in the future.

In taking a sample of cream from the vat to determine the content of butterfat or the acidity, it is essential not only to mix the cream in the vat thoroughly but to remove portions from various parts of the vat and mix these portions together.

In sampling butter in the churn portions should be taken at 8 to 12 places from one end of the churn to the other end, and the several portions worked into a homogeneous mass of about the consistency of petrolatum.

In the following description of methods of quantitative analysis most commonly used in creameries for determining the amount of butterfat in cream and buttermilk, the proportions of butterfat, moisture, salt, and curd in the butter, and the acidity of sour cream for standardization with a neutralizing agent, it is assumed that the samples have been properly taken.

THE BABCOCK TEST FOR FAT IN CREAM

Equipment and materials required:

One Babcock tester.
Cream test bottles, which are graduated in units of 0.5 percent.
Commercial sulphuric acid (specific gravity 1.82 to 1.83).
One cream pipette, capacity 9 cc.
One acid measure.
One Fahrenheit thermometer.
One water bath.
One cream scale with weights.
Glymol.
One pair of dividers for reading graduations on bottles.

Procedure:

Place a cream test bottle on the pan of the cream scale and accurately balance the scale.
Weigh the correct amount of cream (9 g) into the test bottle.
Add from 5 to 7 cc of water which has a temperature of about 70° F.
Some testers prefer to add the water after the acid has been added. In either case, the object of using water is to prevent too vigorous action of the acid and subsequent charring of fat.

Procedure—Continued

Add from 10 to 15 cc of acid in small amounts to the mixture of cream and water, until the characteristic brown color appears after the contents have been well mixed by shaking the bottle with a circular motion. The proper color for the mixture of cream, water, and acid is a coffee brown, which develops rather slowly.

Centrifuge in the Babcock tester for 5 minutes; then to each bottle add hot water up to the base of the neck; centrifuge for 2 minutes; add enough hot water to bring all the fat within the scale on the neck; and centrifuge for 1 more minute.

Frequently in commercial work only a first centrifuging and one filling followed by a second centrifuging are made. This procedure will suffice if indications point to a clear test; otherwise the former procedure is preferable.

Remove the bottle from the tester and place in a water bath at 130° to 140° F. The water level should be above the top of the fat column. Let stand in the water bath for 5 minutes.

Add 3 or 4 drops of glymol, and make the reading at once. The glymol destroys the meniscus or curved surface at the top of the fat column, making it flat. With a pair of dividers measure the exact length of the column of fat; then, taking care not to change the spread of the dividers, place one point on the zero mark of the bottle-neck scale and the other point of the dividers will register the percentage of fat in the cream.

Precautions:

Mix the cream sample by pouring from one vessel to another 4 or 5 times.

Do not make the mistake of measuring cream by volume into the test bottle, as this will introduce an error. Always weigh it in the test bottle.

See that the tester is properly balanced. If a test bottle is placed in one cup, place another in the position directly opposite. Both bottles should contain approximately the same amount of the mixture of cream, water, and acid. A similar amount of some other liquid, preferably water, may be added to an empty cream test bottle when it becomes necessary to equalize the number of bottles placed in the tester.

The temperature of the cream and acid used should be between 60° and 70°F.

If the acid is too strong, use slightly less than usual.

If the acid is too weak, use slightly more than usual.

Mix the acid and the cream as *soon* as the acid has been added. It is usually advisable to add the acid a little at a time, and mix thoroughly after each addition until the correct amount has been added. In adding acid, let it flow down the side of the neck instead of dropping it directly on the cream, as there is less danger of charring and violent action.

Acid destroys clothing and burns flesh. *Be careful.* If acid drops on your hands, wash it off. If it drops on the clothing touch the spot as soon as possible with dilute ammonia or alkali, and wash off.

Keep the acid bottle stoppered at all times.

Always oil the Babcock tester before using it.

Run the tester at the proper speed. If it is run too fast, bottles may be broken. If it is run too slowly, the fat reading may be too low.

Foam sometimes appears on top of the fat column. This defect is usually corrected when the bottles are placed in the water bath and the glymol is added.

A milky or charred layer beneath the fat column is usually due to improper use of the acid. The former fault may be caused by using too weak acid, the latter by too strong acid, or acid that is too hot when added, or by improper mixing of the acid and cream. When a milky or charred layer appears the determination should be repeated.

THE NORMAL BUTYL ALCOHOL-BABCOCK TEST FOR FAT IN BUTTERMILK

Equipment and materials required:

The equipment and materials required are the same as for determining the butterfat content of cream with these exceptions:

(1) Double-neck skim-milk bottles, reading to 0.01 percent, in place of the cream test bottles.

Equipment and materials required—Continued

(2) Glymol is not used in reading the fat column.

In addition there will be required:

One pipette, capacity 2 cc.

One pipette, capacity 8.8 cc.

Normal butyl alcohol; a little more than one half pint will suffice for approximately 120 determinations.

Procedure:

Transfer 2 cc of normal butyl alcohol to a double-neck test bottle.

Add 8.8 cc of buttermilk and mix thoroughly.

Add 7 to 9 cc of sulphuric acid, a few cubic centimeters at a time, and mix thoroughly after each addition.

Centrifuge for 2 minutes and fill the large neck with water which will bring the fat layer into the small neck where it can be read on the scale.

Centrifuge for 2 minutes.

Remove the bottles from the tester, place them in a water bath heated to between 130 and 140° F. for 5 minutes, and read at once. Take the reading by measuring the fat column from the bottom to the extreme top.

Multiply the reading by 2, which gives the percentage of fat in the buttermilk.

Precautions:

Avoid mixing the buttermilk and acid in a way that causes the mixture to be thrown up into and out of the small neck of the bottle. If this should happen, the contents of the bottle should be emptied and a new determination made.

THE KOHMAN METHOD FOR DETERMINING THE COMPOSITION OF BUTTER

Equipment and materials required:

One butter-moisture scale.

One 10-gram weight.

One graduated cylinder, capacity 250 cc.

One steel spatula with a 3-inch blade.

One alcohol lamp or other convenient device for heating the sample.

One aluminum cup, capacity about 250 cc.

One pair of tongs for holding cup.

One pipette with a capacity of 5 cc graduated in tenths of a cubic centimeter.

One pint of wood alcohol.

Five pounds of petroleum ether.

Potassium chromate solution for indicator, made by dissolving 10 grams of potassium chromate in enough water to make 100 cc of solution.

Silver nitrate solution, made by dissolving 29.06 g of silver nitrate in enough water to make exactly 1,000 cc. of solution. CAUTION: Only pure distilled water which shows no turbidity upon addition of silver nitrate solution should be used. It is advisable to purchase the potassium chromate and silver nitrate solutions from a reputable supply house.

The following procedure is based on the use of a scale equipped with two beams graduated in percentages, one beam reading to 10 percent and the other to 20 percent. If the scale used is equipped with one 10 percent and one 100 percent beam, the percentage of butterfat is obtained directly instead of by difference and the modifications in this procedure are very simple.

Procedure:

Adjust the butter-moisture scale by moving the rider on the 10 percent beam to the 10 percent mark. Slide the rider on the 20 percent beam to the zero mark.

Place an aluminum cup on the right-hand pan and balance. (Two cups may be used to facilitate balancing.)

On the left-hand pan place the 10-g weight, and weight 10 g of well mixed butter into the cup on the right-hand pan.

Procedure—Continued

Heat the butter in the cup until all moisture has been evaporated. This point is reached when the butter shows few bubbles, turns golden-brown, and ceases foaming. At this point a few cracking sounds come from the material in the cup.

Allow the cup and contents to cool, replace it on the right-hand pan of the scale and reweigh by moving the rider on the 20 percent beam to the point that will balance the scale. The reading represents the percentage of moisture. Record this figure and return the rider on the 20 percent beam to the zero mark.

To the material in the cup add 100 cc of petroleum ether. Stir thoroughly but carefully with a clean, rubber-tipped, glass rod to avoid splashing. *Avoid flames at all times.*

Let the mixture stand 4 minutes, and carefully pour off the petroleum ether, which contains the fat. Repeat the process with an additional 100 cc of petroleum ether. CAUTION: This part of the determination should be performed in bright natural light or the light of an electric bulb. Extreme care must be exercised to avoid pouring off any of the residue.

Heat the residue until it becomes powdery by placing the cup on a "low heat" electric hot plate. Allow the cup and contents to cool to room temperature.

Replace cup on the right-hand pan of the scale. Remove the 10-gram weight from the left-hand pan, and balance the scale by moving the rider on the 10 percent beam backwards towards its zero mark. Subtract this reading from 10. The result indicates the percentage of salt and curd.

The difference between 100 and the sum of the percentage of moisture and the percentage of salt and curd represents the percentage of fat in the butter, thus:

Moisture	percent	15.8
Curd and salt	do	3.5
Total moisture, salt, and curd	do	19.3
Butterfat (100—19.3)	do	80.7

To determine the salt content of the butter, add 176 cc of distilled water to the salt and curd in the aluminum cup. Stir thoroughly, and draw off 17.6 cc of the mixture and transfer to a white cup. Add 3 drops of potassium chromate indicator solution, and titrate with silver nitrate solution as follows:

With the 5 cc pipette measure the silver nitrate solution drop by drop into the white cup containing the salt and potassium chromate solution until a permanent brownish-red color appears. Each cubic centimeter required represents 1 percent of salt.

METHOD FOR DETERMINING ACIDITY OF CREAM, SKIM MILK, WHEY, BUTTERMILK, AND WHOLE MILK

The following method for determining the acidity of cream is also used for determining the acidity of whole milk, skim milk, whey, and buttermilk.

Equipment and materials required:

Tenth-normal sodium hydroxide solution (alkali). This should be obtained already prepared from a supply house.

One white cup.

One pipette, capacity 9 cc.

Phenolphthalein solution (indicator) made by dissolving 10 g of the powder in 300 cc of denatured alcohol.

One burette, capacity 50 cc, graduated to 0.1 cc, for measuring the alkali solution used.

Burette clamp and support.

A burette which attaches directly to the alkali bottle may be obtained.

Procedure:

While various modifications are used in commercial laboratory work, the following general procedure is satisfactory:

Place 9 cc of cream (or whole milk, skim milk, whey, or buttermilk) in a white cup, and rinse out the pipette with warm distilled water, also adding these rinsings to the cup.

Add 3 drops of phenolphthalein indicator solution.

From the burette run in slowly the standard alkali solution, constantly stirring the mixture in the cup until it turns to a permanent faint pink color. This is the end point and all acid is neutralized.

Read on the scale of the burette the volume of tenth-normal sodium hydroxide used. Each cubic centimeter of sodium hydroxide solution used represents 0.1 percent lactic acid in the cream, and 0.1 cc represents 0.01 percent acid. For instance, a reading of 5.6 cc indicates that the sample had an acidity of 0.56 percent. In other words, the percentage of acid may be obtained by dividing the number of cubic centimeters of sodium hydroxide solution used by 10.

With viscous, gassy, or foamy cream, a 9 g sample should be weighed out instead of measured in order to attain accuracy.

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